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Project Management in Civil Design of a Daycare and Preschool

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Project Management in Civil Design of a Daycare and Preschool

by

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Abstract

This report is an overview of a civil design process, based on the example of a Kiddiegarten School of Maple Grove project; it shows how to plan and manage a construction project, how to do project's economic analysis; how to perform civil design.

Careful financial planning should be done before any construction. Net present value and internal rate of return methods were used to determine if the project brings any return on investment.

Work breakdown structure and responsibility matrix were the first steps for defining the project; the project timeline was created next and main milestones defined.

Civil design started with an extensive requirements research and best available technologies analysis. Preliminary design included a set of plans and supportive documents for the PUD approval application in the City of Maple Grove.

The project shows good return on investment during the stable state. The plans were submitted on time and approved by the City of Maple Grove.

The project results can be used for future design and project management work on similar facilities.

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Chapter I: Introduction

Introduction

Increasing importance of early education and insufficiency of child care centers caused high demand for these facilities. To satisfy the increasing needs and to provide a high quality child care services a new state-of the-art facility was designed.

The project design process was complicated and creative; it had strict budget and time frames. The application of some project management and economic analysis tools for a design of a modern preschool and child care center was described in this project. Civil design requirements analysis formed a significant part of the research. Deep research was done to find the best available storm water management technology for the project site. Based on the requirements a set of civil design plans was created.

Methodology, collected data, data analysis and results were presented and organized to show three sides of the project: project management, economic analysis and civil design.

Economic analysis revealed that child care projects have a big economical potential, and contribution to local economy. Applied project management technics allowed for project successful completion. Project results might be used to perform future design work in similar conditions.

Problem Statement

Lack of the existing in the area child care facilities and high demand for early childhood education created a necessity of additional facilities to satisfy rising demand. These created a need of new facility to serve the neighboring area. The proposed facility should include desired adequate play space and high building functionality, which are vital to the success of a modern daycare and preschool.

Nature and Significance of the Problem

It is now widely recognized, especially by parents, that quality early childhood education pays high dividends. Wilder Research (2012) noted that without early education and support for healthy development, an at-risk child is more likely to start school at a disadvantage and ultimately more likely to drop out of school, earn lower wages, depend on public assistance, or commit crimes.

Currently there are very few child care centers to serve for the child care needs of the community around the proposed location. Within the 3-mile radius, there are only five centers with a combined capacity of 364 children versus 2,444 children of just up to 4 years of age (Table 1). In addition, many new residential and office developments are planned around the proposed location.

The project will generate employment to approximately 30 full-time equivalent (FTE) employees and it will contribute towards City's revenues due to taxes.

Table 1

Child Care Centers within 3 Mile Radius and Demographic Projections

Child Care Centers within 3-Miles Radius:	
New Horizon Academy, 16750 91st Ave N, Maple Grove 55311 Bright Beginnings Christine Preschool, 9350 Upland La N, Maple Grove 55369 Radiant Montessori School, 8801 Rice Lake Rd, Maple Grove 55369 Shining Light Preschool, 9200 Elm Creek Blvd, Maple Grove 55369 New Horizon Academy, 1 Scimed Place, Maple Grove 55311	364 (Total Capacity)
Demographic Projections for 2016 within 3-Mile Radius (by Esri, retrieved from: http://www.esri.com/data/esri_data):	
Population 0-4 Years Population 5-9 years	2,444 2,765

The project will also help the community by providing high quality child care services with some unique features, at their doorsteps in a growing area where such services are very limited.

The project will also contribute towards overall growth and development of the Maple Grove City. Calculations of economic indexes will help to identify feasibility of investment in this field in economically developed country.

Some innovative civil design solutions could be used in other projects with similar characteristics.

Applied Project Management principles for the time and resource constrained project can be beneficial for the future project management activity.

Objective of the Project

The objective of the project is to identify the economic feasibility of the new facility; to design the Child Care Center with capacity of 138 children at the proposed 2.19 acres site, located at 9495 Garland Lane North, Maple Grove, MN 55311; including customized ~11,000 SF building in Phase 1 and ~7000 SF building in Phase 2; to create all the required plans and documents for every stage of design and new development approval process, meeting client’s requirements, City’s codes and regulations, time and budget targets, using the best available solutions.

Project Questions/Hypotheses

Project included problem solving in three different but interrelated spheres: project management, engineering economy and civil design.

Engineering economy.

- Is chosen site location beneficial for the chosen business type and why?
- What kind of benefits this business will bring to the community and investor?
- How much starting capital should be to design, build, start facility operation?
- Will the project realization bring any profit?

Project management.

- What does this project include? What is needed to be done?
- What are main project milestones, deadlines?

Civil design.

- What are the City of Maple Grove requirements for the new construction in this development zone?
- What is the specific of this project to be considered in civil design?
- What are the requirements for storm water and other utilities design?

Limitations of the Project

This paper does not focus on all of the project lifecycle stages; only on the first three (market demands and perceived needs, conceptual planning and feasibility study, design and engineering) stages were analyzed. The design stage of this project paper is limited to only design for the Planned Unit Development application for the City of Maple Grove, MN.

Some of the economic calculations were omitted; cost and revenue data provided by the project owner was used as a base for future calculations.

Project only included civil design planning and implementation; architectural and other engineering solutions were not part of this project.

Significant number of calculations and initial data for storm water management was not presented in this project due to a big volume of reports.

Definition of Terms

Feasibility studies. Assessment of the reasonableness of proposed development.

Design. It is a process of creating the depiction of a new facility, represented by detailed plans and specifications.

Planned unit development (PUD). A type of building development and a regulatory process.

Conceptual design process. It is a systematic series of steps that engineers use in creating products and processes.

Critical path. Project management technique for scheduling projects; it identifies tasks which need to be completed on time for the whole project to be completed on time.

Net present worth. It is a characteristic, used to determine the present value of an investment by the discounted sum of all cash flows received from the project.

Internal rate of return (IRR). It is 'the rate that equates the cost and benefit of the project in terms of present value; it is the maximum cost of the financing of the investment'.

Work breakdown structure (WBS). Identifies all the activities that must be executed to complete the objectives of the project.

Impervious surface. Hard surfaces, which do not infiltrate storm water.

MPCA. Minnesota Pollution Control Agency.

BMP. Best Management Practices (regarding best storm water management in this project).

Summary

Problem significance, problem statement, project limitations, project questions and definition of terms were covered in the chapter. The next chapter will present background of the problem, and literature review related to the project management in construction projects, feasibility studies, and methodology.

Chapter II: Background and Review of Literature

Introduction

This chapter will introduce some of the design project details, project owners and responsible organizations. It will include literature review related to the problem and methodology used for data collection and data analysis.

Background Related to the Problem

The new development project name is Kiddiegarten Child Care Center, project site located in Maple Grove, MN. The project is about new development of Child Care Center for children from 6 weeks to pre-KG years of ages, with a proposed design capacity of 138 children at the proposed site 9495 Garland Lane North, Maple Grove, MN 55311 (see Figure 1).

Figure 1. Project location.

It is proposed to conduct a customized building of approximate 11,300 SF in Phase 1 of the project in total land parcel size of 2.19 acres. This will be followed up by Phase 2 of the project with similar capacity.

Proposed total capacity of the child care center is around 140 kids and 30 teachers.

The project is sponsored by a group of professionals willing provide service to the community through quality education.

The project aims to provide several uncommon features such as large indoor play area, a very large outdoor play area, organic food etc. at the cost of additional revenue opportunities to the owners.

Project will be planned and constructed in two stages; this will require additional design planning and second phase foreseeability in design itself.

The part of the entire project, analyzed in this paper, mainly concentrated on civil design. The civil design was done by one contractor; architectural plans were done by two architectural design companies, some other contractors were involved to conduct smaller tasks.

Project development has very inflexible timeframe during the design stage, due to land purchase due to diligence time constraint.

Literature Related to the Problem

There are some critical challenges project managers facing nowadays: deliver faster, save more, manage the data, communicate effectively, think big (Akio, 2015). These challenges are common for large-scale projects, but appear in small-scale projects also. This creates a necessity for integrated work of owners, engineers, and civil designers who can work in parallel, share data, and build quality and efficiency into every project (Akio, 2015). These challenges call for effective project management.

Project planning. From the perspective of an owner, the project life cycle for a constructed facility may be illustrated schematically on Figure 2. First of all the project should be built around market demands or needs in a timely fashion (Hendrickson, 2008).

Each stage requires technical and managerial knowledge. Cost of operation and maintenance as parts of the project lifecycle should be considered as much as costs of construction, planning and design.

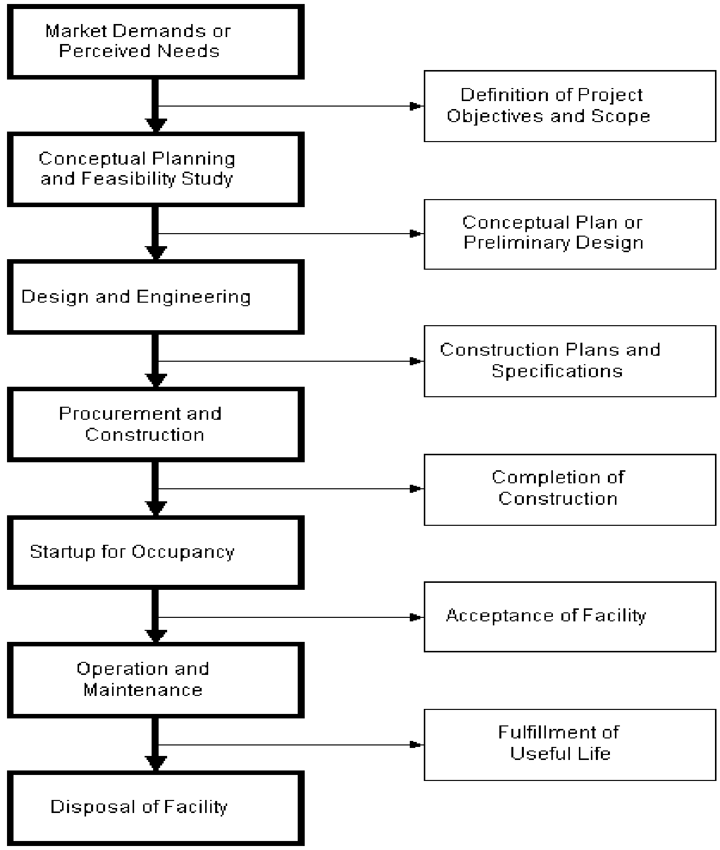

Figure 2. The project life cycle of a constructed facility (Hendrickson, 2008).

Project design and construction. According to Hendrickson (2008), design is a process of creating the description of a new facility, usually represented by detailed plans and specifications; construction planning is a process of identifying activities and resources required to make the design a physical reality. Construction is the implementation of a design envisioned by architects and engineers (Hendrickson, 2008).

Some characteristics should be kept in mind at the very early stage of the project life cycle (Hendrickson, 2008):

- Usually every facility is custom designed, and most likely it will require a long time to complete.
- Design and construction of a facility are based on a specific site conditions (natural, social and other locational conditions).
- The service life of a facility is long, so the anticipation of future requirements might be very difficult.
- Changes of design plans during construction are common.

Innovation and economic feasibility. Conceptual design includes: formulation, analysis, search, decision, specification, and modification (Hendrickson, 2008). Figure 3 shows, that at the early development stage, these actions are highly interactive.

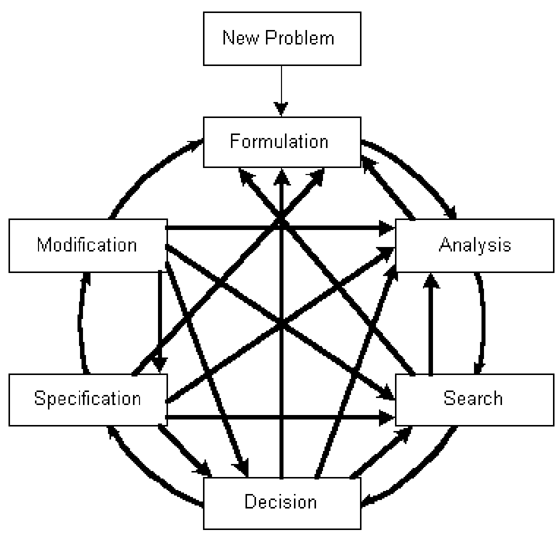

Figure 3. Conceptual design process (Hendrickson, 2008).

Following actions should be taken in the conceptual design process (Hendrickson, 2008):

- Formulation–definition of a design problem in broad terms.
- Analysis–refines the problem definition, separates important from peripheral.
- Search–gathering potential solutions.
- Decision–obtain the best solution out of potential solutions by their evaluation and comparison.
- Specification–detailed explanation of chosen.
- Modification–change in the solution or re-design if the solution.

The basic approach to design relies on decomposition and integration. Design problems are large and complex, according to Hendrickson (2008) they have to be decomposed to sub problems, which are small enough to solve:

- Top-down design. Begin with general description of the facility and work towards descriptions of its components.
- Bottom-up design. Start with a set of constituents, and see if they can be combined to meet the project goal.

Civil design projects deal with higher uncertainties and require different management technologies than routine operations (van Rijn, 2004). In each project three kinds of activities will take place (Larson & Gray, 2011; van Rijn, 2004; Wysocki, 2011):

1. Decisions, about the project results, impacts and resources;
2. Work on substance (outputs, activities, tasks);

3. Managing resources (time, budget, information and project staff) and controlling quality.

Client should be involved widely in all design stages for the construction projects. The plan checker do not have as much time to check plans; engineer and approval agency should work together as a team to assure a good project and plans understanding from approval agency side, to create the project without a need for design changes, to serve the community and to provide good return of investment for the developer. Project Manager's role is to provide all necessary communication (van Rijn, 2004).

Project should have a work plan, listing all the tasks; after the project plan was done, project schedule can be created; after determining all activities and tasks, the project manager may start allocating resources to activities and specific tasks (Ohio University, n.d.; van Rijn, 2004).

Network plans can be presented in two ways: Activity on the Arrow (critical path method) and Activity in the node (PERT chart) (van Rijn, 2004).

In engineering project management work should be organized, performed and finished on time. To make sure that the project team stays on schedule the time for each task should be deduced. Project Evaluation and Review Technique (PERT) is used to determine the time frame; first all the tasks should be mapped, then sequenced to lead to milestones. The project manager then determines the maximum and minimum amount of time each event will take from start to finish using a complementary method to PERT called the Critical Path Method (CPM) (Ohio University, n.d.).

Engineering design usually done in two major phases: preliminary design and detailed engineering design (Ogunlana, Lim, & Saeed, 1995). This paper focuses on preliminary design phase. Preliminary design stresses architectural concepts, evaluation of design alternatives, size and capacity decisions, and comparative economic studies (Ogunlana et al., 1995).

Conceptual planning and feasibility design stage are very important for construction projects. In projects where this stage was omitted, the project scope can be inadequately defined (Hendrickson, 2008). Changes in project scope later during the project life will increase construction costs (Hendrickson, 2008).

Landers of capital want to be assured that the project will offer good return of investment.

According to Hendrickson (2008), costs of a constructed facility for the owner include initial expenses, operational and unexpected costs (Table 2).

Table 2

Construction Project Costs (Hendrickson, 2008)

Initial Establishment Expenses	Operation and Maintenance Cost	Unexpected Costs
• Land acquisition • Planning and feasibility studies • Architectural and engineering design • Insurance and taxes during construction • Construction (materials, equipment and labor) • Field supervision of construction • Construction financing • Owner's general office overhead • Equipment not included in construction • Inspection and testing	• Financing costs • Land rent, if applicable • Operating staff • Labor and material for maintenance and repairs • Insurance and taxes • Periodic renovations • Utilities • Owner's other expenses	• Schedule adjustments • Design development changes, • General administration changes (such as wage rates), • Differing site conditions for those expected, • Third party requirements imposed during construction

Careful financial planning must be made prior to construction, because direct construction costs usually represent approximately 60% to 80% of the total costs (Hendrickson, 2008).

As shown in Figure 4 below, early stage decisions of the owner have the crucial influence on the construction costs, rather than those on later stages. Therefore, an owner should provide adequate planning and feasibility studies (Hendrickson, 2008)

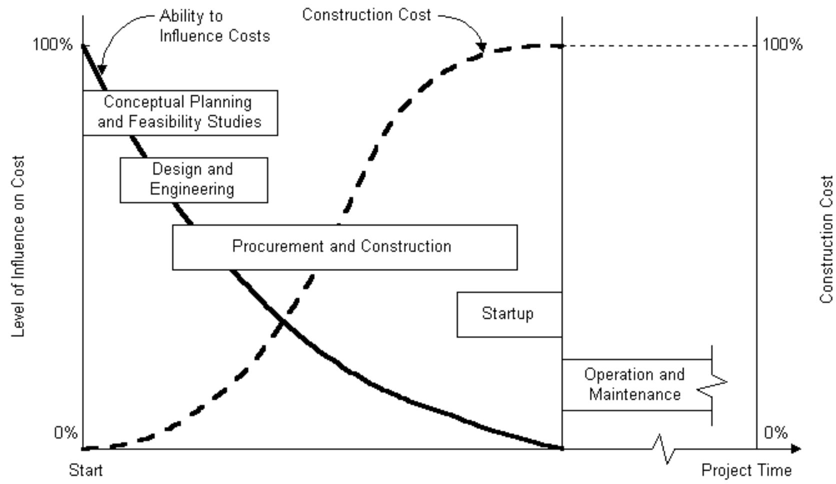

Figure 4. Ability to influence construction cost over time (Hendrickson, 2008).

Basically there are three types of cost estimates (van Rijn, 2004), all with different level of accuracy:

1. Rough estimate;
2. Indicative estimate;
3. Detailed estimate.

The project estimate can include all three or each individually (van Rijn, 2004).

Investment projects involve expenditure of resources in exchange of future benefits (profits, cost savings, social benefits) (Allen, 1991). In some projects the consumer benefits will exceed the owner's revenues.

Cost of child care in Minnesota vs. other states. As per report published by Childcare Aware of America (2014), Minnesota average annual fees for full-time care in a center for infant is US$13,993 (vs. U.S. range of $5,476-$16,549), and that for a 4-year-old child is $10,812 (vs. US range of $4,515-$12,320). State of Minnesota is the fifth highest in terms of child care fees after District of Columbia, Maryland, Massachusetts and New York. Further, average annual income of child care workers in Minnesota is $21,710 vs. a U.S. average of $21,320, and state of Minnesota ranks 18th as compared to all the U.S. states. While not considering other factors, this means a higher gross profit for the child care business, as salaries of the child care workers forms a big part (i.e., about 2/3rd) of the operating cost.

The owner sets the overall policy and selects the suitable organization to take charge of a proposed project and perform project management. According to Hendrickson (2008) and van Rijn (2004), there are three most typical ways to separate the project into stages:

- Sequential processing (linear). The project is divided into separate stages, completed in a sequence.
- Parallel processing. The project is divided into independent parts such that all stages are carried out simultaneously.
- Staggered processing whereby the stages may be overlapping (cycling).

According to the survey results, retrieved from Hendrickson (2008), the key factors for successful projects are: well defined scope, extensive early planning, good leadership, management and first line supervision; positive client relationship with client involvement, proper project team chemistry, quick response to changes, engineering managers concerned with the total project, not just the engineering elements.

Literature Related to the Methodology

Economic evaluation. Before starting the design process, economic evaluation of the desired project should be completed. During the design process, proposed design ideas should also be evaluated.

Basic financial evaluation tools are Net Present Worth (NPW) and Internal Rate of Return (IRR) (Naquib, 2007). They answer two most important questions: What is the cost (expenditure)? And what is the return (reward)? According to Naquib (2007), engineers should understand the concepts of project finance, in order to argument new design solutions implementation into a project.

Other evaluation tools include: Net Future Value, Equivalent Uniform Annual Net Value, Benefit Cost Ratio, Adjusted Internal Rate of Return, Return on Investment, Payback Period (Hendrickson, 2008).

NPV is used to determine the present value of an investment by the discounted sum of all cash flows received from the project (Net present valud, n.d.). If a project shows a positive outcome, it is accepted (Balaji, 2010).

Internal rate of return (IRR) is 'the rate that equates the cost and benefit of the project in terms of present value; it is the maximum cost of the financing of the investment' (Balaji, 2010).

Project management. Work breakdown structure detects all the activities that must be performed to achieve the objectives of the project. A WBS is an important tool for cost assessments, creating schedules, organizing work, reporting/ tracking/controlling (U.S. Department of Energy, 2003).

Before the project scheduling all the work of the project should be identified, it helps to include all work, without omitting anything in order to fit in delivery dates, see Figure 5 below.

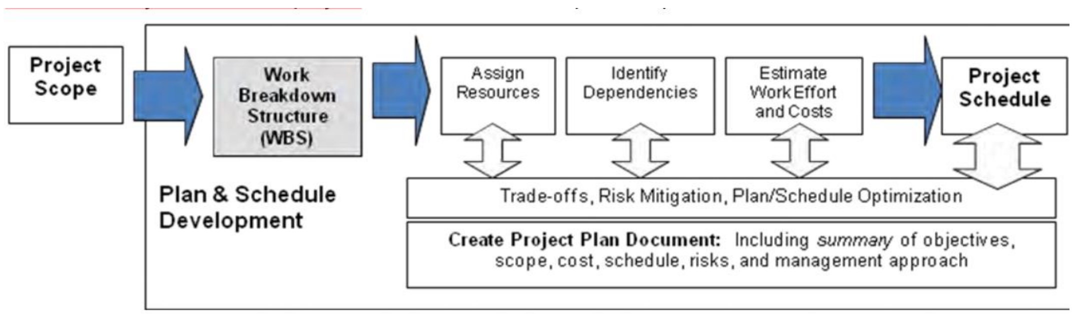

Figure 5. Plan and schedule development (U.S. Department of Energy, 2003).

WBS key objectives, according to Emprend (2001, 2007, 2008): WBS gives a rational view of the volume of work required; provides a basis for required skills and resources identification; offers a base to assign responsibility; lays a foundation for studying dependencies and for handling risks and for developing a bottom-up estimate for the project schedule.

This is a team process and should not be done by the Project Manager alone. The main goal of WBS is to identify and accurately plan all of the work needed to meet the project's objectives (Emprend, 2001, 2007, 2008).

Project WBS and organizational breakdown structure may be used to develop a project responsibility assignment matrix, which identifies individual work responsibility and authority and serves as a basis for identifying, planning, progressing, and reporting the work of other organizations (subcontractors, suppliers), for preparing progress reports; developing budgets, schedules, and milestones; tracking costs and spending (U.S. Department of Energy, 2003).

Civil design rules. Since primary this is a design project in Maple Grove City, the main City rules for new construction should be overviewed. Code of Ordinances (Maple Grove, Minnesota–Code of ordinances, 2016) constitutes a recodification of the general and permanent ordinances of the City of Maple Grove. Special attention was given to the Chapter 8 (Buildings and Building Regulation), it included a number of Articles, describing the process of new construction, remodeling, demolition etc. in the City of Maple Grove. Chapter 32 (Traffic) was used to plan new parking lot and street exit/entrance. Chapter 34 (Utilities) information was used to design utilities network for new buildings. Chapter 36 (Zoning) dictated rules for construction.

The construction project will involve land disturbing activities on the site, and will have to go through The Elm Creek Watershed Management Commission; so the storm water management on the site will have to comply with Elm Creek Watershed Management rules. Appendix O, Rules and Standards of the Commission's Second Generation Management Plan Minor Plan Amendment (Elm Creek Watershed Management Commission, 2015) lists rules, requirements and recommendations to the storm water management. The review of these rules is critical before implementation of any storm water management technology.

Increase in impervious surface increases the surface runoff volume, less volume infiltrates and reaches aquifer; runoff carries pollutants, which together with sediments if reach surface water will create buildup of silt and pollution. If the area of soils disturbance is more than 1 acre, then Erosion Control Plan is needed, to provide assurance that pollutants will not reach surface waters (Colley, 2005).

To choose the best available storm water management technology, the MPCA guidance “Protecting Water Quality in Urban Areas” (MPCA, 2000) could be used as one of the reference documents, but more detailed research should be done after checking the site’s soils condition, and calculating the amount of storm water, forming on the impervious surfaces of the proposed buildings and parking lots.

MPCA guidance “Protecting Water Quality in Urban Areas” (MPCA, 2000) gives the idea how urbanization affects the storm water quality and quantity, what are the BMPs and how to select them, erosion prevention and sediment control, pollution control.

It describes different Stormwater treatment concepts, including the treatment train approach to BMP selection. Treatment train approach is a multi-BMP approach for managing the quantity and quality of stormwater runoff, it is a combination of treatment practices, selected BMP might contain several practices, depending on the site’s specifics, requirements and budget (MPCA, 2016).

Examples of treatment trains: green roof, Permeable pavement, Bioretention, Swales, Swirl concentrator, Stormwater wetland and others (MPCA, 2016). On-site treatment trains considered to be the most effective, they maintain runoff onsite and allow sufficient time for hydraulic, physical, biological, and chemical (MPCA, 2016).

Chapter 4 of MPCA guidance “Protecting Water Quality in Urban Areas” (MPCA, 2000) describes variety of storm water best management practices, their advantages and disadvantages, implementation, design, etc. All practices can be divided into next general groups: Flow Controls, Vegetative Stabilization, Bioengineering, Structural Stabilization, and Filtration Practices. The choice of solution for every project should be based on site specific, runoff volume, requirements, budget, etc.

Infiltration is extensively supported practice, because it has long-term value in managing storm water. Infiltration techniques deliver several benefits (as identified in the Minnesota Storm Water Manual): 1) reducing the volume of storm water runoff; 2) controlling and improving water quality; 3) recharging groundwater; 4) mitigating thermal effects on cold-water fisheries; and 5) attenuating peak flows (Ramsey-Washington Metro Watershed District, n.d.).

One of the filtration practices is infiltration trench, it is an excavated trench, usually 2 to 10 ft. backfilled with a coarse stone aggregate, which stores runoff in the voids between stones. Stored runoff then infiltrates into the surrounding soil. Trench trapps pollutants, but not soluble substances. This practice can be very effective for reducing the volume of runoff from a site of limited size (MPCA, 2000).

The latest research (Ramsey-Washington Metro Watershed District, n.d.) shows the benefits of using tire derived aggregate for the infiltration structures backfill instead of conventional materials, TDA (New Technology Review, 2016) provides higher void space (50%), in compare with rock material (30%-40%). Cost of TDA is less than the cost of sewer rock, and it is a recycle material.

There is a variety of available stormwater models (MPCA, n.d.). Three of them were used in the project: PONDNET, P8, and HydroCAD.

The PONDNET model is an empirical model developed to evaluate flow and phosphorous routing in Pond Networks (MPCA, n.d.).

P8–Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, is a physically-based stormwater quality model created by William Walker to forecast the generation and passage of stormwater runoff pollutants in urban watersheds. The model simulates runoff and pollutant transport, 24 stormwater best management practices (BMPs) and 10 water quality components can be used in calculations (MPCA, n.d.).

HydroCAD is a computer design program, which models the hydrology and hydraulics of stormwater runoff. The program computes runoff hydrographs, routes flows through reservoirs, and combines hydrographs at confluences of the watershed stream system (MPCA, n.d.).

Summary

Background of the problem, including construction project idea, responsible parties, desirability of this service; and literature review were covered in this chapter. There are many published sources how to perform economical evaluation of a project; how to plan work on the construction project; there are many documented design rules for the project area (Minnesota State, City of Maple Grove), described in rules and regulations, recommendations from different government agencies.

Detailed methodology for chosen feasibility study, project management and design will be covered in the next chapter.

Chapter III: Methodology

Introduction

The objective of the project is to identify the economic feasibility of the project; to plan and manage design work; to create all the required plans and documents for every stage of design and new development approval process according to the City and customer requirements, using the best available solutions, meeting time and budget targets.

There are few steps needed to be done to achieve the objective:

- **Economic studies** were done using next methods: IRR and NPW. The project costs should include design, construction, operation, management costs, along with costs associated with possible risks (Twort & Rees, 2004).
- **City requirements overview.** City codes and rules overview to prepare all necessary development documents and plans.
- **Best design practices overview.** Overview and comparison of the best design practices for storm water management, site planning, landscaping, traffic control, etc.; to implement the best suitable solutions for this site.
- **Project planning.**
- **Project civil design.** Developing plans using AutoCAD, according to design requirements and rules; calculations for the storm water management solutions using HydroCAD, PondNet and excel spreadsheets.

Design of the Study

The study for this design project used quantitative and qualitative approaches. Economic studies were based on quantitative analysis, some areas of design studies used qualitative approach also. Project management used both. Many of the design decisions were based on requirements, facts and solutions non quantitative analysis. The combination of both approaches is the best solution for complex design projects.

Data Collection

I. **How to plan work on the design project** (based on recommendations from Colley (2005) and Larson and Gray (2011):

Meet with the client. To define the project scope.

Create a contract. List the scope of work, responsibilities, additional consultants if needed; the fee for the services provided; ownership for drawings, breach of contract, late payment and interest, errors and insurance. Contract ideally should be prepared by legal professional.

Define the fee. There are 3 ways to define the fee for engineering services: cost per person hours, fee per sheet of drawing, percentage from the total construction cost.

Things to consider when calculating the cost: the complexity of the job; workload of the company; whether the client will take more time; whether the client will negotiate for lower fee.

Explain to the client what does the fee includes, so it does not look too high.

Existing conditions. Investigate and verify existing site conditions.

Plan the project. Plan the schedule and identify the critical paths.

Coordinate the work on the project between different contractors, consultants.

Identify criteria. City and County ordinances, rules from other institutions, clients' and other involved engineers' criteria. Some of them cannot be changed–those are critical points, give them special attention when plan the work.

Planning criteria–setbacks. It is a critical point, setbacks should be determined initially, rarely they can be changed, buildings and other structures size calculated assuming these setbacks.

Timing. Is very important in development projects, time constrains should not affect the quality of work.

Topography survey should be start as soon as the contract is signed. It will give the true boundary, topography, existing utilities, roads, etc., on the site.

Errors and omissions. To avoid costly construction delays and design errors fixing when construction started, thorough research of existing and proposed facilities is necessary.

II. Obtain following information for future site analysis

Zoning considerations.

Existing plans for streets and utilities. Plans might belong to the city or County; it is reasonable to obtain plans for the development site and adjacent sites.

Find the location of existing: gas, water, telephone, electricity, sewer, storm water lines and possible connection points. Contact utility companies and City to obtain those.

III. How to perform economic evaluation of facility investments

Use 2 methods to perform economic evaluation of a project: NPV and IRR.

Data collection to perform economic analysis:

Identify net present value of project’s benefits and costs, use owner’s data, calculated using earnings and revenue projections.

Find depreciation and loan interest payment.

Find estimated capital cost from the project owner.

IV. Collect requirements for effective civil design, include following information

What are the City of Maple Grove requirements for the new construction in this development zone? Use City resources to collect building, parking, setbacks requirements.

Which documentation needs to be submitted for Non-Residential Planned Unit Development Application approval? Use City informational resources.

V. Identify what does this project include and what is needed to be done

Create work breakdown structure, which identifies all the activities that must be executed to complete the objectives of the project.

WBS creation top-down approach, according to Emprend (2001, 2007, 2008):

1. Identify the major components of work to be accomplished. Identify 5-10 major work groups to form the top level of your WBS. There are seven possible approaches for WBS organization (Wysocki, 2011): physical decomposition, functional decomposition, design-build-test-implement, objectives, geographical, business function, departmental.

   Use the best for this project approach.
2. Identify the next level of work (Level 2) under each major component.
3. Continue to break down the work under each Level 2 item.

Systematically check WBS for completeness, considering the project scope (if everything from the project scope was met), stake holders (are the needs and interests of all stakeholders met), events, which can have positive or negative effect on the project, team roles and responsibility allocation matrix.

WBS elements should be: Definable, Manageable, Estimable, Independent, Integratible, Measurable, And Adaptable (U.S. Department of Eneergy, 2003).

Create project responsibility assignment matrix–a table, which describes who is responsible for executing specific work element from WBS (U.S. Department of Eneergy, 2003).

Identify main project milestones.

Plan and schedule work on the project: use Gantt chart (Microsoft project tool).

VI. Identify design rules for the utilities network

Utility lines needed by civil design: water, sanitary, storm sewer**.** Use codes, regulations, published materials.

Collect requirements for the storm water management on the site. Use Elm Creek Watershed information recourses for requirements, and published information for management practices analysis and application. Review pollutant removal processes and identify potential practices.

Collect existing site conditions for future analysis: soils, infiltration coefficients from soil or geotechnical reports.

Collect information regarding proposed conditions (proposed hardcover area, slopes, etc.).

Collect all the required input for the storm water management solutions calculations using software products: PONDNET (e.g., watershed area (acres), runoff coefficient, pond surface area (acres), pond mean depth (feet), period length (years), period precipitation (inches) and phosphorous concentrations (ppb)), P8, HydroCAD.

Data Analysis

I. How to perform economic evaluation of facility investments

Use 2 methods to perform economic evaluation of a project: NPV and IRR.

Net present value method. Use following formula to calculate NPV (according to (Balaji, 2010).

$$NPV_x = BPV_x - CPV_x$$

$$NPV_x = \sum_{t=0}^{n} \left(B_{t,x} - C_{t,x}\right)(P|F,i,t) = \sum_{t=0}^{n} A_{t,x}(P|F,i,t)$$

Where:

BPV_x - the present value of benefits of a project

CPV_x - the present value of costs of the project

MARR = i over a planning horizon of n years.

$$CPV_x = \sum_{t=0}^{n} C_{t,x}(1+i)^{-t} = \sum_{t=0}^{n} C_{t,x}(P|F,i,t)$$

Calculate the present value of benefits, using following formula:

$$BPV_x = \sum_{t=0}^{n} B_{t,x}(1+i)^{-t} = \sum_{t=0}^{n} B_{t,x}(P|F,i,t)$$

Where

(P|F,i,t) is a discount factor equal to $(1+i)^{-t}$ (Balaji, 2010)

The project is acceptable as long as (Balaji, 2010)

$$NPV_x \geq 0$$

To simplify calculations, use the same input in Excel and function NPV to calculate net present value.

Consider depreciation and tax effects when calculating NPV. To consider tax effects in project evaluation, the most direct approach is to estimate the after-tax cash flow and then apply an evaluation method such as the net present value method (Hendrickson, 2008).

IRR method. IRR is the discount rate that causes the net present value of future cash flows from an investment to equal zero (Accounting Simplified, n.d.).

IRR can be calculated using the Microsoft Excel IRR function. Write the cash flows of the investment in separate cells and define the range of those cells in the IRR function (Accounting Simplified, n.d.).

If the calculated internal rate of return is greater than the return requirement, the project is accepted. If IRR is less than the market-rate of money, the project proposal is rejected (Balaji, 2010).

II. Site analysis

Analyze the following data: Zoning requirements, how to maximize the land use under this requirements.

Define existing inverts and locations of utilities from existing utilities and street plans. Elevations on different sets of plans might have been taken from different benchmarks, verify elevations and verify depth of manholes.

Verify if connections to existing lines is possible, based on their original planned capacity, verify with the City and County.

Check the location of existing: gas, water, telephone, electricity, sewer, storm water lines and possible connection points. Contact utility companies and City to obtain those.

Visit the site and make notes. Verify the location of existing utilities on site and on plans.

III. Plan and schedule work on the project

Use Critical Path Analysis, based on WBS and project milestones.

IV. Analyze and address requirements for effective civil design and apply findings to create a set of desired drawings

Analyze how to maximize the value of land by rational land use:

1. Consider Setbacks
2. Calculate required parking spaces, area, required driveways, islands, turns; get the required parking lots area.
3. Calculate the area of required playground space

4. Consider storm water management facilities requirements and best available technologies.
5. Consider supporting utilities requirements, locations, areas.
6. maximize the building size based on the area, left after subtracting parking lots, setbacks, playgrounds; utilities according to the building planned capacities and construction budget.

Analyze requirements for the storm water management on the site.

Analyze best management practices for storm water management, chose the best suitable method:

1. Review project goals and site conditions, including: analysis of Elm Creek Watershed regulatory requirements for the new development sites, analysis of existing conditions (soils, infiltration coefficients), analysis of proposed conditions (proposed hardcover area, slopes etc.).
2. Review pollutant removal processes and identify potential practices (MPCA, 2016):
   - Select processes required to manage pollutants. Identify combination(s) of BMPs that include the processes required to manage the identified pollutants;
   - Determine site constraints that affect BMP placement and sizing;
   - Available space;
   - Access for maintenance;

- Limitations on infiltration related to soil type, soil contamination, depth to groundwater, presence of structures, utility conflicts, and/or depth to bedrock;
- Regulatory requirements that affect the BMP volume or footprint;
- Compatibility with other site uses, including green space requirements, public spaces, structures, etc.;
- Select individual BMPs and evaluate range of performance;
- Size BMPs and assess performance;
- Calculate site runoff, necessary storage, pollutants volume (method described below);
- Review construction and operation criteria;
- Make sure the results comply with the requirements;
- Finalize the storm water management design.

Runoff annual volume and pollutant loads calculations method. Calculate for three scenarios: predevelopment conditions, post development conditions without mitigation, and post development conditions with mitigation.

Calculate total phosphorus in storm water. Calculate for Before Development based on 0.4 lbs / acre / year, as provided by the Watershed for grasslands; After Development (before treatment) calculate based on 600 ppb and annual stormwater run-off volume as described below; and

After Development (with treatment) calculate based on two approaches: PONDNET and P8 software products.

Calculate total suspended solids (TSS). Calculate using P8 model.

The annual stormwater runoff volume, pollutant loads for TSS, dissolved phosphorus, and particulate phosphorus are calculated following the runoff reduction method developed by the Center for Watershed Protection & Chesapeake Stormwater Network, which is based off the Simple Method (MPCA, 2016).

The runoff reduction method calculates the annual runoff stormwater volume (R) in cubic feet based on the following:

$R=DR*A*3630$

Where:

D_r is the annual runoff depth in inches;

A is the total watershed area in acres;

3630 is a conversion factor of to convert the final result to cubic feet.

The total watershed area (A) is an input parameter supplied by the user. The annual runoff depth D_r, is calculated using the following

$Dr=P*Pj*Rv$

Where:

P is the total annual rainfall depth in inches (35in.);

P_j is the fraction of annual rainfall events that product runoff; and

R_V is the runoff coefficient which is dimensionless (0.95).

The total annual rainfall depth (P) should be determined based on zip code (35in, Maple Grove) for the state of Minnesota.

The annual runoff volume was used to calculate the pollutant loads from the site. The pollutants loads (L) in pounds were calculated with the following

$L=R*C*6.243*10-5$

Where

R is the annual runoff volume in cubic feet;

C is an average annual pollutant concentration in mg/l; and

$6.243 * 10^{-5}$ is a conversion factor of to convert the final result to pounds

Use HydroCAD software tool to analyze acceptability of chosen storm water management technology. HydroCAD is an integrated solution for the analysis, design, and documentation of complete drainage systems using standard hydrograph techniques.

Based on the complex requirements analysis, according to project plan create a set of required drawings for submission.

Budget

Investment capital for design and construction was provided from the project owner. The project had limited budget.

Timeline

The timeline for the project is described in the Table 3 below.

Table 3

Project Timeline

Task	Start Date	End Date
New development City of Maple Grove requirements review	05.01.2015	06.01.2015
Literature review	05.01.2015	06.01.2015
Methodology analysis	06.01.2015	6.15,2015
Project economical parameters calculation	06.15.2015	07.01.2015
Project design timeframes planning	07.01.2015	7.15.15
PUD development application package preparation	07.03.2015	08.03.2015
Land Survey and Civil Plans development for the PUD development stage plan submission	08.03.2015	11.02.2015
Watershed application submission package preparation	09.03.2015	11.02.2015
Finalizing plans for construction	11.02.2015	12.01.2015
Construction start	12.01.2015	06.01.2016
Project conclusions and findings	01.01.2016	03.01.2016
Project defense		Summer, 2016

Summary

This chapter described general methodology for construction work planning, used in this project; methodology for economic analysis, site analysis, civil design process, storm water management calculations and strategy and project timeline. Data analysis will be covered in the next chapter.

Chapter IV: Data Presentation and Analysis

Introduction

All collected data for economic analysis, project planning, civil design will be shown in this chapter in the data presentation section.

This chapter also presents data analysis and results interpretation. It shows the results of economic studies; results of storm water management solutions analysis and final set of drawings, displaying all the design solutions.

Data Presentation

I. Financial analysis input data

Financial analysis input data is presented in the Table 4 below.

Table 4

Revenue and Earnings Projections (provided by the project owner).

Item	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Month 13	Month 14	Month 15	Month 16	Month 17
*All values are in thousands of dollars																	
Capital Cost	3,500																
Total Revenue	15	31	46	59	72	87	101	112	123	134	145	153	160	167	174	181	188
Total Expenses	53	62	67	72	80	85	97	98	106	107	112	117	117	122	122	127	131
Loan Interest Payment	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Depreciation (Building)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Data collected is based on owner’s revenue and earnings projections calculations; building depreciation and loan interest.

II. City of Maple Grove requirements for the new construction

City of Maple Grove requirements for the new construction are summarized in Table 5.

Table 5

City of Maple Grove Requirements for the New Construction

Type of Requirement	Development Zone	Design Requirements According to City Regulations	Regulation Document
Land Use	in red shaded zone (figure 6 below) Mixed use development	Principal land use types: office buildings; high-density housing; major retail centers; civic buildings. Vertical mixtures allowed and encouraged. Review as a planned-unit development.	City of Maple Grove Land Use Plan (retrieved from : http://www.maplegrovemn.gov/files/9813/7003/4955/2012_Land_Use_Plan_8x11_and_table.pdf)
Zoning	R-5 PUD zone	Daycare conditional use is accepted if the following requirements are met: a. No overnight facilities. b. Front yard depth shall meet the minimum in the respective district. c. Adequate off-street parking and access shall be provided. d. Adequate off-street loading and service entrances shall be provided. h. License approval from the regulatory welfare agency must be supplied to the city.	City's Zoning Map (retrieved from: http://www.maplegrovemn.gov/files/7914/1200/7430/2014_ZoningMap_20x24.pdf) Sec. 36-414 (Maple Grove, Minnesota - Code of Ordinances, 2016)
Lot Setbacks	R-5 PUD zone	Building setbacks : Back of the lot: 100ft Side: 10 and 30 ft. Front: 30 ft. Parking setbacks: Front: 20ft Side: 10ft and 20ft Back: 40ft	section 36-415 (Maple Grove, Minnesota - Code of Ordinances, 2016)
Building requirements	R-5 PUD zone	No structure in the R-5 district shall exceed three stories or 35 feet in building height, whichever is greater, except as otherwise provided for in this division.	Sec. 36-416. - Building requirements (Maple Grove, Minnesota - Code of Ordinances, 2016)
Parking requirements		*Parking space size:* 18 feet in length exclusive of access aisles, and each space shall be adequately served by an access aisle. *Number of parking spaces:* Schools, high school through college, and private and day or church schools: At least one parking space for each seven students based on design capacity plus one for each three classrooms.	Sec. 36-868. - Required number of parking spaces (Maple Grove, Minnesota - Code of Ordinances, 2016)

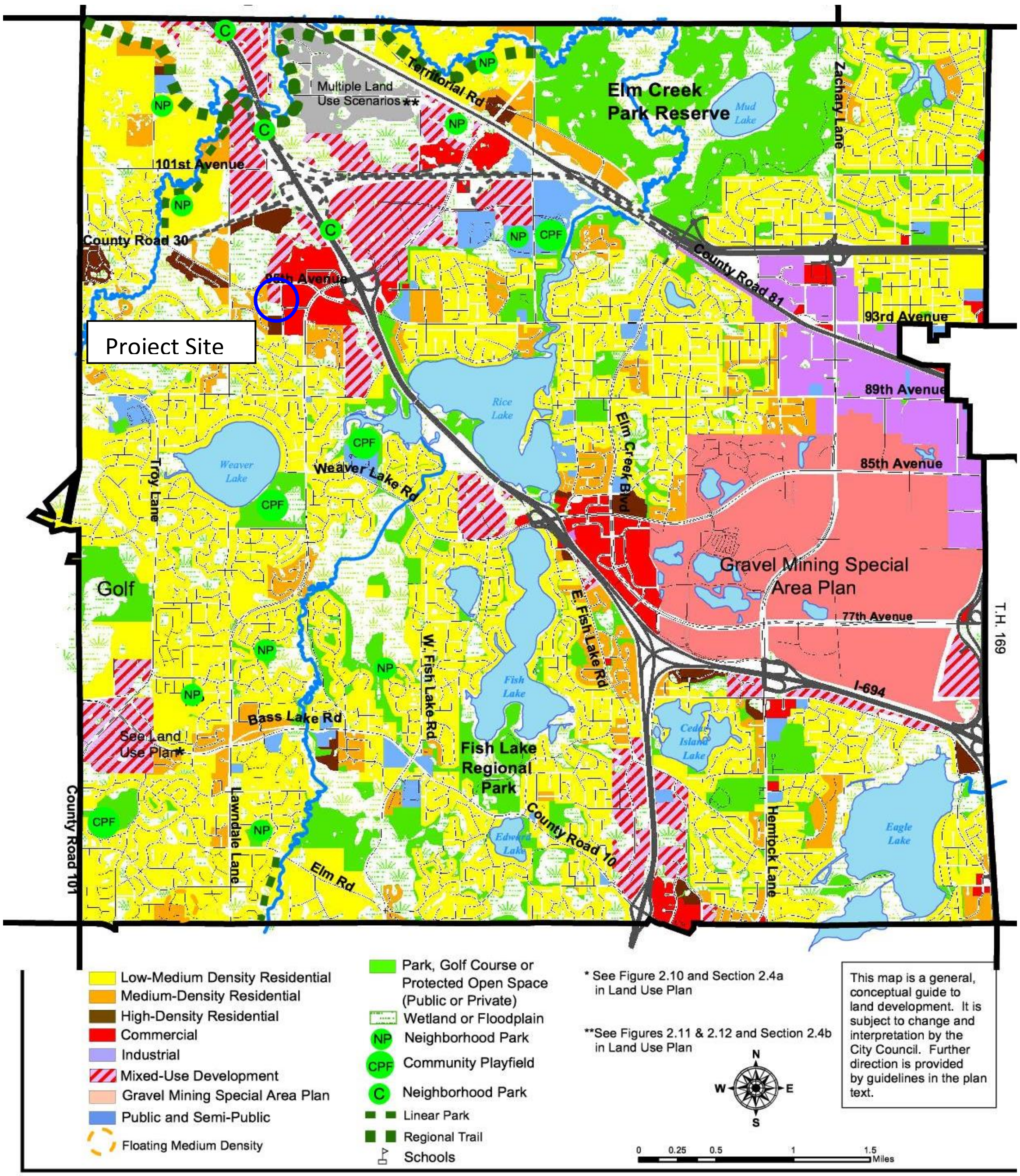

Figure 6. Maple Grove Land Use Plan (2012).

III. PUD development stage approval procedure

The owner should submit to the city Non-Residential Planned Unit Development application. The list of documents and requirements for them are summarized in a table 6 below.

Table 6

The List of Required Documents for PUD Approval Procedure City of Maple Grove

#	Completed Document
1	Legal description of the property
2	Narrative of Project. A written statement generally describing the proposed subdivision / PUD and the market which it is intended to serve
3	Acknowledgement of Responsibility form
4	Affirmation of Sufficient Interest form
5	Application to appropriate Watershed District
6	Names and addresses of property owners within 500' of subdivision requested, certified by the Auditor of Hennepin County (mail letter to Hennepin County Government Center OR order by phone 612-348-5910)
7	15 folded copies - Concept Plan
8	15 folded copies - Development Stage Plan

All of the above required information must be submitted at least 28 days prior to a Planning Commission meeting to ensure review by the Planning Commission on that date. According to the 2015 Planning Commission Meetings calendar, the submission date should be no later than 11.02.2015.

Need to plan work accordingly to create all plans in compliance with City requirements and meeting the submission deadline.

IV. Requirements for the development stage plans and watershed application

Requirements for development stage plans and watershed application are summarized in a Table 7 below.

Table 7

Requirements for the Development Stage Plans and Watershed Application

Plan Name	Design Requirements (Plan Should Include)
Proposed Design Features Sheet (Site Plan)	Locations of all proposed buildings Locations of all sidewalks, trails, or other hard surfaces Minimum building setback lines as required in chapter 36 (Maple Grove, Minnesota - Code of Ordinances, 2016) shall be shown. Locations of trash receptacles Any other details necessary to tell the story of the development.
Grading and Drainage Plan	Existing and proposed contours Proposed building locations, lot lines, parking lot features, roads, sidewalks, etc. Provision for surface water disposal, drainage, and flood control that complies with applicable ordinances, statutes and governmental regulations shall be included.
Utility Plan	Locations of proposed sanitary and storm sewer lines and water mains shall be shown. Water mains shall be provided. Service connections shall be stubbed into the property line and all necessary fire hydrants shall also be provided. Sanitary sewer mains and service connections shall be installed in accordance with the city's comprehensive sewer plan, as amended.
Landscape plan	Location, approximate size and common name of existing trees and shrubs. Planting schedule containing: i. Symbols. ii. Quantities. iii. Common names and botanical names. iv. Size of plant materials. v. Root condition (balled and burlapped, bare root, container, etc.). vi. Special planting instructions. Planting details illustrating proposed locations of all new plant material. Locations and details of other landscape features, including, but not limited to, berms, fences and planter boxes. Location and details of irrigation systems. Impervious surface analysis showing the % of the property that is impervious

Plan Name	Design Requirements (Plan Should Include)
	Details and cross sections of all required screening. Such other information as the city may require.
Application to the Watershed District	
Erosion and Sediment Control Plan	gradients of waterways, design of velocity and erosion control measures, landscaping of the erosion and sediment control system and stabilization of disturbed areas
Stormwater Management Plan	Quantity: Plans must include drainage areas, direction of runoff, and computations for runoff before and after development, and with peak control. Development in the Elm Creek watershed shall not alter the peak discharge and timing of runoff resulting from a 2-, 10-, and 100-year rainfall event of the critical duration for that subwatershed. Quality: A water quality protection plan, prepared by a qualified individual, shall delineate and identify drainage areas based on the elevations proposed in the grading plan and the proposed stormwater conveyance system for each area. The plan shall include details for all best management practices proposed for treatment of runoff from the site. The plan shall also include a schedule of implementation for the proposed treatment practices.

V. Requirements for the utility system design

Utility lines needed by civil design: water, sanitary, storm sewer. On the project plan all the locations of existing and proposed utilities should be shown along with their dimensions and capacity. Main Requirements are shown in the Table 8.

Table 8

Critical Requirements for the Utility System Design

Utility Line	Critical Requirements	Reference
Sewer & Storm	Sewer sizes should be designed for the peak flow.	(Colley, 2005)
	Depth and slope are designed for gravity flow.	
	Inverts should be shown on the plan, so when other utility lines will be designed, the crossing conflicts will be solved before the work is done.	
Sewer	Manholes should be designed where the sanitary main connects or where there is a change of direction of the sewer line, with the angle less than 130 degrees; change of grades or every 450ft. Manholes should be 4-5 ft. diameter, to allow the maintenance. Manufactured standard manhole sets can be used. The inside bottoms of sanitary manholes should be constructed fir smooth flow.	
	The sewer should be designed on elevations as shallow as possible to keep the necessary slope and avoid crossing conflicts.	
	Design starts 5ft from the building.	
	The sewer main should be deep enough to provide the sewer flow from under the building foundation with the slope no less than 2%. If the gravity flow is not feasible for the site, pressure systems can be used to pump the sewer.	
	Sewer laterals should be avoided to go through the structures, it'll cause additional expenses.	
	When central sewage facility cannot be reached economically, on-site sewage treatment can be used.	
Horizontal sewer separation	Gravity sewer should be located 10 feet, measured horizontally from a watermain.	(City Engineers Association of Minnesota, 1999a)
Vertical separation	Bottom of the watermain should be at least 18 inches above the top of the sewer. When watermain crosses sewer it is preferred that the watermain cross above sewer.	
Water supply	Water supply lines are force mains (pressure lines), they are not dependent on gravity, so they can go over or under other facilities and lines.	(Colley, 2005)
Horizontal and vertical location	It depends on protection of freezing, potential contamination, crushing. Water lines should be placed 6ft from the face of the curb, 2 ft. from the property line. If the site is higher than surrounding, check if the water pressure will be enough. Water lines cannot be placed in a joint trench with sanitary, and storm. Tees and wyes should be used for pipes connection, pre-manufactured elbows – for bands. Limited variety of elbows, restricts the design. Where the profile changes from negative to positive, bubbles might accumulate, preventing the water flow, in that location a drain or blow-off valve may be required. Gate valves should be used to stop the water flow in various locations.	
Water Demand	Fire protection should be considered when calculating water demand.	

VI. Stormwater management requirements summary

Elm Creek Watershed requirements:

The construction project involves land disturbing activities on the site, and has to go through The Elm Creek Watershed Management

Commission; so the storm water management on the site has to comply with Elm Creek Watershed Management rules. Appendix O, Rules and Standards of the Commission's Second Generation Management Plan Minor Plan Amendment (Elm Creek Watershed Management Commission, 2015) lists rules, requirements and recommendations to the storm water management. The review of these rules is critical before implementation of any storm water management technology.

There are several main requirements needed to be implemented by the project.

1. According to the Rule D of Appendix O (Elm Creek Watershed Management Commission, 2015), proposed peak runoff rates cannot exceed existing conditions.
2. Runoff rates should be controlled by the on-site or regional facilities.
3. All proposed and existing structures efficiency should be reviewed based on the 1% (100-year) critical storm event. Fourth, runoff cannot be discharged to the water bodies without treatment. Fifth, the best effort should be applied to infiltrate the runoff volume.

There are three main criteria the storm water management plans should comply with:

1. Runoff rate restrictions (proposed runoff cannot exceed existing).

2. Volume control requirements. 1.1’’ of stormwater runoff from impervious surface should be infiltrated on site during first 48 hours of rain. It can be reached by minimization of impervious surfaces, implementation of infiltration facilities. The infiltration rate may be measured using percolation test, or derived from coefficients based on the site’s soil type, using the MPCA table (MPCA, 2016).
3. Water quality requirements. There shall be no net increase in total phosphorus (TP) or total suspended solids (TSS) from pre-development land cover to post-development land cover (Elm Creek Watershed Management Commission, 2015).

The project creates big area of impervious surfaces (parking lots, roofs), which will create a significant amount of runoff; based on the above criteria, and the site conditions, design had to implement some best stormwater management practices to comply with watershed requirements.

Basic input parameters for storm water calculations. Basic project parameters fir the runoff calculations are shown in the Table 9.

Table 9

Basic Project Parameters for the Stormwater Calculations

Parameter	Value
Total Parcel Area	2.19 acre
Total New Impervious Area	55%
Volume Extraction Requirements	0.11 Acre-feet
Total Irrigation Area (except playground)	0.6 Acre

Input parameters for PONDNET, P8 and HydroCAD calculations not presented in this paper due to big volume.

Data Analysis

I. Project management

To analyze the workload, project structure and responsibilities work breakdown structure based on deliverables (Table 10) and Responsibility Matrix (Table 11) were created.

Table 10

Work Breakdown Structure

1. Project Kiddiegarten School of Maple Grove for PUD Application			
1.1. Initial Assessment			
	1.1.1. Legal Description		
		• Obtain the Title document for the property • Write legal description	
	1.1.2. Narrative	• Write project narrative document • Include economic studies describing the proposed subdivision / PUD and the market which it is intended to serve	
	1.1.3. Acknowledgement of Responsibility form	• Fill out the template	
	1.1.4. Affirmation of Sufficient Interest form	• Fill out the template	
	1.1.5. Names and addresses of property owners within 500' of subdivision requested	• Obtain information from Hennepin County	
	1.1.6. Concept Plan	• Create a general design concept plan	
1.2. Civil Design Phase			
	1.2.1. Development Stage Plan		
		1.2.1.1. Land Survey	• Obtain legal information about the site • Site Field Work • Drafting • Check
		1.2.1.2. Site Plan	• Define Setbacks • Locate structures • Research BMPS for storm water management • Draft • Check
		1.2.1.3. Grading Plan	• Requirements study • Stormwater management solutions • Erosion control methods during Construction • Erosion Control after Construction • Draft • Check
		1.2.1.4. Utility Plan	• Requirements study • Sanitary sewer • Water • Storm water • Draft • Check

		1.2.1.5. Details	• All details for the set of plans • References • Check
		1.2.1.6. Landscape Plan	• Tree calculations • Species analysis • Location • Draft • Check
		1.2.1.7. Architectural Plans (out of scope)	• Building sizes
		1.2.1.8. Mechanical Plans (out of scope)	
	1.2.2. Application to Watershed District		
		1.2.2.1. Erosion Control Plan	• Erosion prevention during construction • Erosion prevention after construction
		1.2.2.2. SWPPP	• Based on the calculations 1.2.2.3
		1.2.2.3. SWM Calculations	• Drainage area calculation • Runoff calculations • HydroCAD • PondNET • P8 • BMPs analysis for stormwater treatment

Table 11

Responsibility Matrix

Deliverable	Organization
1.1.1.Legal Description	Licensed Surveyor, EDS, Inc.
1.1.2. Narrative	Project Owner with the project manager
1.1.3. Acknowledgement of Responsibility form	Project Owner
1.1.4. Affirmation of Sufficient Interest form	Project Owner
1.1.5. Names and addresses of property owners within 500' of subdivision requested	Project Owner
1.1.6. Concept Plan	EDS, Inc. Architect
1.2.1.1. Land Survey	EDS, Inc.
1.2.1.2. Site Plan	EDS, Inc.
1.2.1.3. Grading Plan	EDS, Inc.
1.2.1.4. Utility Plan	EDS, Inc.
1.2.1.5. Details	EDS, Inc.
1.2.1.6. Landscape Plan	EDS, Inc.
1.2.1.7. Architectural Plans (out of scope)	Inspire Architects, AVA Studio
1.2.1.8. Mechanical Plans (out of scope)	Inspire Architects
1.2.2.1. Erosion Control Plan	EDS, Inc.
1.2.2.2. SWPPP	EDS, Inc.
1.2.2.3.SWM Calculations	EDS, Inc.

II. Financial analysis

Based on NPV and IRR methods, described in methodology, following results were received (Table 12, Table 13).

Table 12

Revenue, Earning, Interest, Depreciation, Amortization

REVENUE & EARNINGS PROJECTIONS ('000 DOLLARS)

Item	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12	Month 13	Month 14	Month 15	Month 16	Month 17
*All values are in thousands of dollars																	
Capital Cost	3,500																
Total Revenue	15	31	46	59	72	87	101	112	123	134	145	153	160	167	174	181	188
Total Expenses	53	62	67	72	80	85	97	98	106	107	112	117	117	122	122	127	131
Earnings before Interest, Taxes Depreciation and Amortization (EBITDA)	**(38)**	**(31)**	**(21)**	**(13)**	**(8)**	**2**	**4**	**14**	**17**	**27**	**33**	**36**	**42**	**45**	**52**	**54**	**57**
Loan Interest Payment	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Depreciation (Building)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Interest, Depreciation, and Amortization	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**
Earnings Before Tax	**(51)**	**(44)**	**(34)**	**(26)**	**(21)**	**(11)**	**(9)**	**1**	**4**	**14**	**20**	**23**	**30**	**32**	**39**	**42**	**44**

Table 13

Cash Flows and PV of Cash Flows for 120 Months

	Discount Rate	5%	(Same as loan rate)	
Month	**Month**	**Cash Flow (thousands of dollars)**	**PV of Cash Flow (thousands of dollars)**	**Cum PV of Cash Flow (thousands of dollars)**
0	Investment	-3500	$3,500	$3,500
1	Month 1	(51)	$51	$3,551
2	Month 2	(44)	$44	$3,595
3	Month 3	(34)	$33	$3,628
4	Month 4	(26)	$25	$3,653
5	Month 5	(21)	$20	$3,673
6	Month 6	(11)	$11	$3,684
7	Month 7	(9)	$8	$3,692
8	Month 8 (Break Even)	1	($1)	$3,691
9	Month 9	4	($4)	$3,687
10	Month 10	14	($13)	$3,674
11	Month 11	20	($19)	$3,655
12	Month 12	23	($22)	$3,633
13	Month 13	30	($28)	$3,605
14	Month 14	32	($31)	$3,574
15	Month 15	39	($37)	$3,537
16	Month 16	42	($39)	$3,498
17	Month 17 (Stead State)	44	($41)	$3,457
18	Month 18	44	($41)	$3,416
19	Month 19	44	($41)	$3,375
20	Month 20	44	($41)	$3,334
21	Month 21	44	($41)	$3,293
22	Month 22	44	($41)	$3,253
23	Month 23	44	($40)	$3,212
24	Month 24	44	($40)	$3,172
25	Month 25	44	($40)	$3,132
26	Month 26	44	($40)	$3,092
27	Month 27	44	($40)	$3,053
28	Month 28	44	($40)	$3,013
29	Month 29	44	($39)	$2,974

Month	Month	Cash Flow	PV of Cash Flow	Cum PV of Cash Flow
30	Month 30	44	($39)	$2,934
31	Month 31	44	($39)	$2,895
32	Month 32	44	($39)	$2,856
33	Month 33	44	($39)	$2,818
34	Month 34	44	($39)	$2,779
35	Month 35	44	($38)	$2,741
36	Month 36	44	($38)	$2,703
37	Month 37	44	($38)	$2,664
38	Month 38	44	($38)	$2,627
39	Month 39	44	($38)	$2,589
40	Month 40	44	($38)	$2,551
41	Month 41	44	($37)	$2,514
42	Month 42	44	($37)	$2,476
43	Month 43	44	($37)	$2,439
44	Month 44	44	($37)	$2,402
45	Month 45	44	($37)	$2,365
46	Month 46	44	($37)	$2,329
47	Month 47	44	($37)	$2,292
48	Month 48	44	($36)	$2,256
49	Month 49	44	($36)	$2,220
50	Month 50	44	($36)	$2,184
51	Month 51	44	($36)	$2,148
52	Month 52	44	($36)	$2,112
53	Month 53	44	($36)	$2,076
54	Month 54	44	($35)	$2,041
55	Month 55	44	($35)	$2,005
56	Month 56	44	($35)	$1,970
57	Month 57	44	($35)	$1,935
58	Month 58	44	($35)	$1,900
59	Month 59	44	($35)	$1,865
60	Month 60	44	($35)	$1,831
61	Month 61	44	($34)	$1,796
62	Month 62	44	($34)	$1,762
63	Month 63	44	($34)	$1,728
64	Month 64	44	($34)	$1,694

Month	Month	Cash Flow	PV of Cash Flow	Cum PV of Cash Flow
65	Month 65	44	($34)	$1,660
66	Month 66	44	($34)	$1,626
67	Month 67	44	($34)	$1,593
68	Month 68	44	($33)	$1,559
69	Month 69	44	($33)	$1,526
70	Month 70	44	($33)	$1,493
71	Month 71	44	($33)	$1,459
72	Month 72	44	($33)	$1,427
73	Month 73	44	($33)	$1,394
74	Month 74	44	($33)	$1,361
75	Month 75	44	($33)	$1,329
76	Month 76	44	($32)	$1,296
77	Month 77	44	($32)	$1,264
78	Month 78	44	($32)	$1,232
79	Month 79	44	($32)	$1,200
80	Month 80	44	($32)	$1,168
81	Month 81	44	($32)	$1,136
82	Month 82	44	($32)	$1,105
83	Month 83	44	($31)	$1,073
84	Month 84	44	($31)	$1,042
85	Month 85	44	($31)	$1,011
86	Month 86	44	($31)	$980
87	Month 87	44	($31)	$949
88	Month 88	44	($31)	$918
89	Month 89	44	($31)	$887
90	Month 90	44	($31)	$857
91	Month 91	44	($30)	$826
92	Month 92	44	($30)	$796
93	Month 93	44	($30)	$766
94	Month 94	44	($30)	$736
95	Month 95	44	($30)	$706
96	Month 96	44	($30)	$676
97	Month 97	44	($30)	$646
98	Month 98	44	($30)	$617

Month	Month	Cash Flow	PV of Cash Flow	Cum PV of Cash Flow
99	Month 99	44	($29)	$587
100	Month 100	44	($29)	$558
101	Month 101	44	($29)	$529
102	Month 102	44	($29)	$500
103	Month 103	44	($29)	$471
104	Month 104	44	($29)	$442
105	Month 105	44	($29)	$413
106	Month 106	44	($29)	$385
107	Month 107	44	($28)	$356
108	Month 108	44	($28)	$328
109	Month 109	44	($28)	$300
110	Month 110	44	($28)	$272
111	Month 111	44	($28)	$244
112	Month 112	44	($28)	$216
113	Month 113	44	($28)	$188
114	Month 114	44	($28)	$160
115	Month 115	44	($28)	$133
116	Month 116	44	($27)	$105
117	Month 117	44	($27)	$78
118	Month 118	44	($27)	$51
119	Month 119	44	($27)	$24
120	Month 120	44	($27)	($3)

NPV = $3.2, project is acceptable.

IRR = 0.4% over 25 years.

Annual return (the ratio of profit and investment) is 10% at a steady state.

III. Storm water management solution analysis

Volume control. Volume control is difficult to achieve, because of the prevailing soil types C and D on watershed, with low infiltration coefficient.

According to the geotechnical report soils on the site are sandy lean clay, and it is hydrologic Type D., with infiltration rates 0.06 inches per hour (Minnesota Stormwater Manual, 2014). This is a very small infiltration rate.

There are several design solutions can be taken into consideration to comply with volume abstraction rule:

1. Infiltration trench. The infiltration trench is proposed for this development site to effectively use the surface space and to avoid using other techniques, which demand big areas. However proposed trench will not be able to infiltrate 1.1 inch of runoff from the impervious surface in 48 hours. But it can retain high volumes of storm water. Trench should store the runoff from a 1-inch rainfall. Storage volume of the trench is provided by the void space between the aggregate particles used for backfill. According to (MPCA guidance “Protecting Water Quality in Urban Areas” (MPCA, 2000) the aggregate backfill should be a clean, washed rock with a minimum diameter of 1.5 inches and a maximum diameter of 3 inches (void ratio ~30 to 40%). To increase the water retension in 2-3 times, the trench might be filled with scrap tire material –Tire Derived Aggregiate (TDA).
2. Pervious pavements. Will reduce runoff volume, but due to soil type will not achieve necessary infiltration.
3. Bio-retention/filtration/treatment. The site doesn’t have enough space to accommodate these methods.

4. Use storm water for irrigation, accumulating water in an underground cistern.

A Stormwater Reuse Credit Calculator developed by “Ramsey-Washington Metro Watershed District (RWMWD) has been used by a consultant to compute the average annual irrigation demand which can be met by stormwater reuse (MIDS Calculator, n.d.) . The total irrigation area at the site is 0.45 acres. The model was run from 1000 gallons capacity to 22,000 gallons capacity in order to determine the most optimum reuse storage volume capacity at corresponding % annual irrigation demand met. The most optimum capacity of the reuse storage volume is between 5,000 to 6,000 gallons. So the irrigation cistern can be installed within the infiltration trench, and provide almost 50% storm water reuse.

Final Solution: Proposed are: Infiltration trench with TDA and stormwater reuse cistern to meet the volume reduction requirement.

Based on the 2.5 inch runoff from the impervious surface physical parameters of the trench were calculated below (Table 14), to provide the capacity to retain required volume of stormwater.

Table 14

Trench Volume Analysis

		(9495 Garland La. N.)									
		Trench Design									
		Information:									
		Proposed impervious surface			53817	sq.ft					
		Increase in paved area from existing to proposed =						**53,817**		**53,817**	sq ft. (1.235 acres)
		Req'd Dead Storage = runoff from 2.5" rain over increase in impervious area =								0.208	ft. (assuming100% runoff)
		Required Dead Storage Volume = area x 2.5" runoff (assuming 100% runoff) =								**11212**	**cu ft.**
		Initial Trench Trial Design:									
	TC	**FL**	**HEIGHT**	**PAV.+SUB.**	TRENCH HEIGHT		AVERAGE	WEIR EL.	HEIGHT		
CB1	**934.14**	**924.7**	**9.44**	**2.75**	6.69		7.88	931.5	6.8		
CB2	**936.11**	**924.3**	**11.81**	**2.75**	9.06			931.5	7.2		
		height	Width	Trench Area	Pipe Diam.	Pipe Area 3.14*D^2/4	Void Area	Total Area	Length	**Volume**	
AVERAGE		7.88	16.00	126.00	1.50	1.77	80.75	82.52	205	16916	
CB1	2' sump	8.8			5	19.63				173	
CB2		14			8	50.24				703	
TOTAL:										**17792**	**cu ft.**
						Average percentage of void		65.49		(F13/D13*100*1+(D13-F13)/D13*100*0.65)	

Rate control. HydroCAD model was used for the rate analysis to calculate combined discharges from the site during different intensity storm events. Existing and proposed conditions were analyzed using HydroCAD.

The following discharge diagrams were used for existing (Figure 7) and proposed conditions (Figure 8).

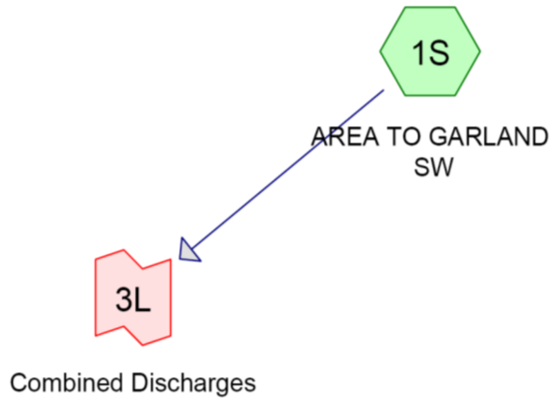

Figure 7. Existing conditions discharge diagram.

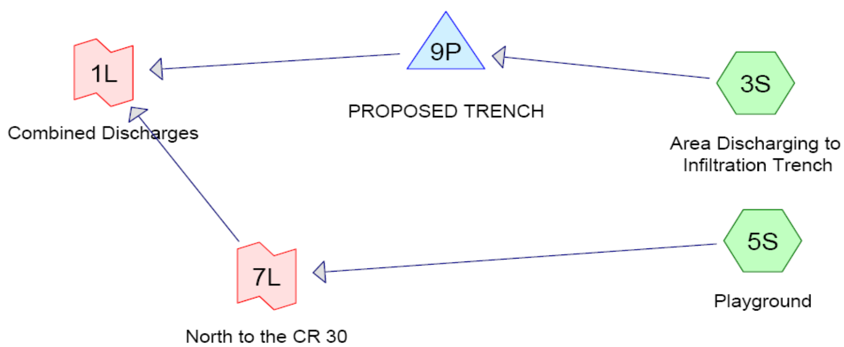

Figure 8. Proposed conditions discharge diagram.

Parameters of all the discharging areas (green), mitigation structures (blue) and discharges characteristics presented in HydroCAD reports (not presented in this paper due to big volume).

According to the requirements combined discharges from proposed development should not exceed existing.

Discharge volumes for different storm events, calculated in HydroCAD (Table 15).

Table 15

Discharge Volumes for Different Storm Events from HydroCAD Calculations

Conditions	2-year event, (cfs)	10-year event, (cfs)	100-year event, (cfs)
Existing	3.42	6.06	12.4
Proposed	1.57	2.71	7.86

Nutrient control. Based on site parameters, chosen storm water management technology parameters, and runoff volume calculation (see methodology), using P8 model and PONDNET following numbers were derived (Table 16).

Table 16

Total Phosphorous and Total Suspension Solids Loads under Different Conditions

Condition	TP Load (lbs./yr) (without Target Pond reduction)	TP Load (lbs./yr) (with Target Pond reduction 60% for 75% IA) Eq. 81.8% for 55% IA	TP Load Prior to Target Pond Reduction (lbs./yr)**	TP Load (lbs./yr)** (with Target Pond reduction 60% for 75% IA) Eq. 81.8% for 55% IA	TSS Load Prior to Target Pond Reduction (lbs./yr)**	Runoff volume (cu ft./yr.)[1]	Runoff volume (AC-ft./yr.)**
Pre-development (baseline) Load	0.876	0.876	1.4	1.4	397.9	12978 cu ft./year	36.4
Post-development Without Mitigation	5.137	0.935	4.7	0.855	1385.7	205306 cu ft./year	103.0[1]
Post-development With Mitigation	1.47*	0.27*	0.9	0.164	95.7	135326 cu ft./year - 668 cu/ft. for irrigation=134658.11 (including irrigation)	42.1

[1] Average annual values

NOTES: *Outflow TP concentrations from the trench based on the NURP pond calculation
** TP load and Runoff calculations based on P8 model.

By analysis of chosen stormwater management scheme, using specialized modeling software, we found the best suitable trench and catch basins parameters; complied with Watershed rules and regulations.

V. Civil design plans production

All the requirements for all necessary plans (see requirements above in data presentation) were analyzed, and plans were designed. Blueprints of some of the designed plans are not presented in this paper; they are intellectual property of the project owner and design company.

Site plan. Using the initial survey plan as a base for a site plan, keeping in mind all the setbacks, calculating required parking spaces, the best way to locate all the structures was analyzed.

Parking calculations were done based on the following information: building capacity -10 rooms, proposed capacity 183 students.

183/7+10=36 parking spaces minimum required.

Total proposed amount of parking spaces for both stages is 79.

The Site Plan was analyzed for requirements compliance.

The first version of the Site Plan presented on Figure 9 below.

The last version, include the finalized buildings, parking lots, trench locations, and details presented on Figure 10.

Grading, drainage, erosion control plan. Existing grades on the site were analyzed, the location of the infiltration trench was proposed on the north site of the parking lot. So the parking lot grades were designed to collect all the storm water to two catch basins (City Engineers Association of Minnesota, 1999b).

By analyzing existing site grades, some depressions, accumulating stormwater were identified; new grading was planned to avoid the stormwater flooding structures, to avoid its accumulation on playgrounds and parking lots.

Based on the storm water management techniques analysis, shown above, integrating it with the site proposed grades, the trench profile and storm water utility lines profiles were added on the plan.

Storm water pollution prevention plan. Based on the requirements for SWPP plan, the following drawing and supportive information were created.

Utility plan. This plans looks the least complicated out of all other plans, but its design was the most complicated. All the requirements for all utility lines design should be met, the most difficult part was to design proposed elevations, assuming proposed surface grades, infiltration trench grades, and characteristics of the city stubs, connection points.

Details sheets. Details were designed to clarify some solutions.

Landscape plan. It had the most amount of changes, since the first version was designed (see Figure 11 below).

City recommendations for allowed tree and bush species were analyzed. The tolerance of the plant species to the site’s soil conditions was considered and esthetic element was important.

The amount of deciduous trees was calculated based on the site perimeter: 1307 LF/ 40 FT (1 tree required per each 40 FT) = 33 deciduous trees. The final plan is shown below (Figure 12).

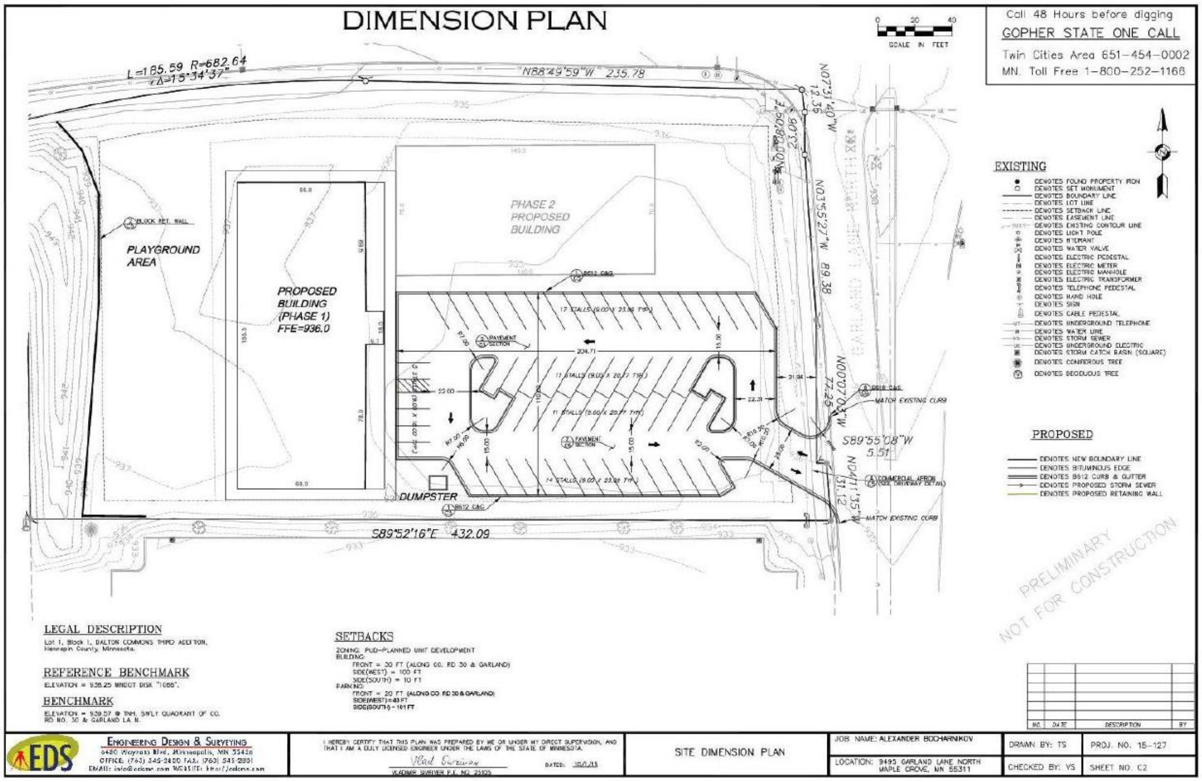

Figure 9. Site plan (First version).

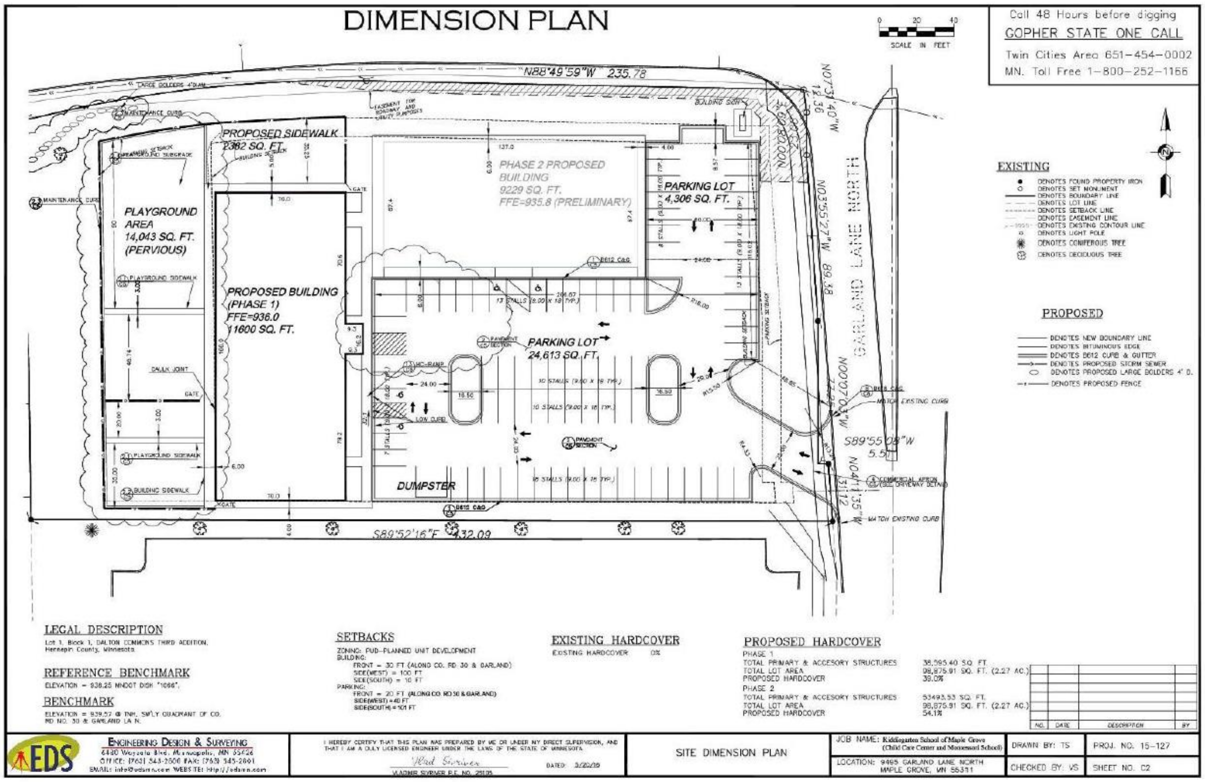

Figure 10. Site plan (Final version).

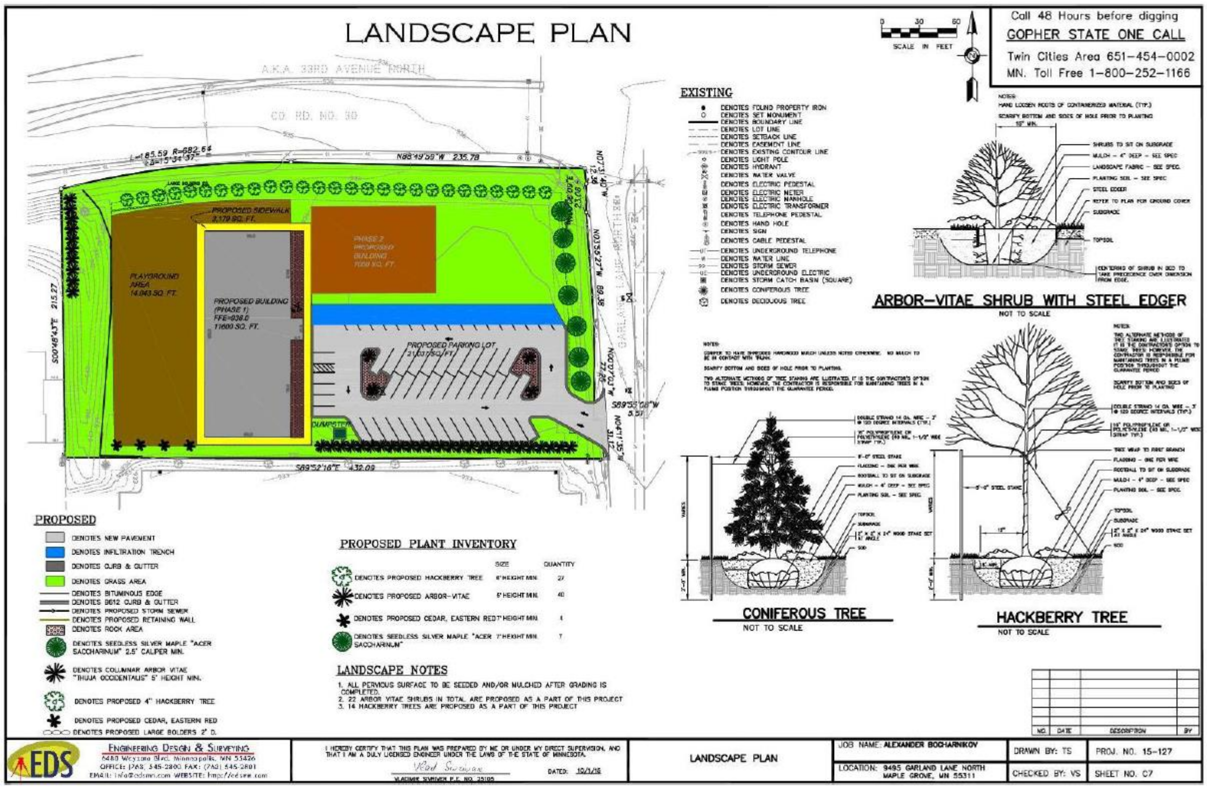

Figure 11. Landscape plan (First version).

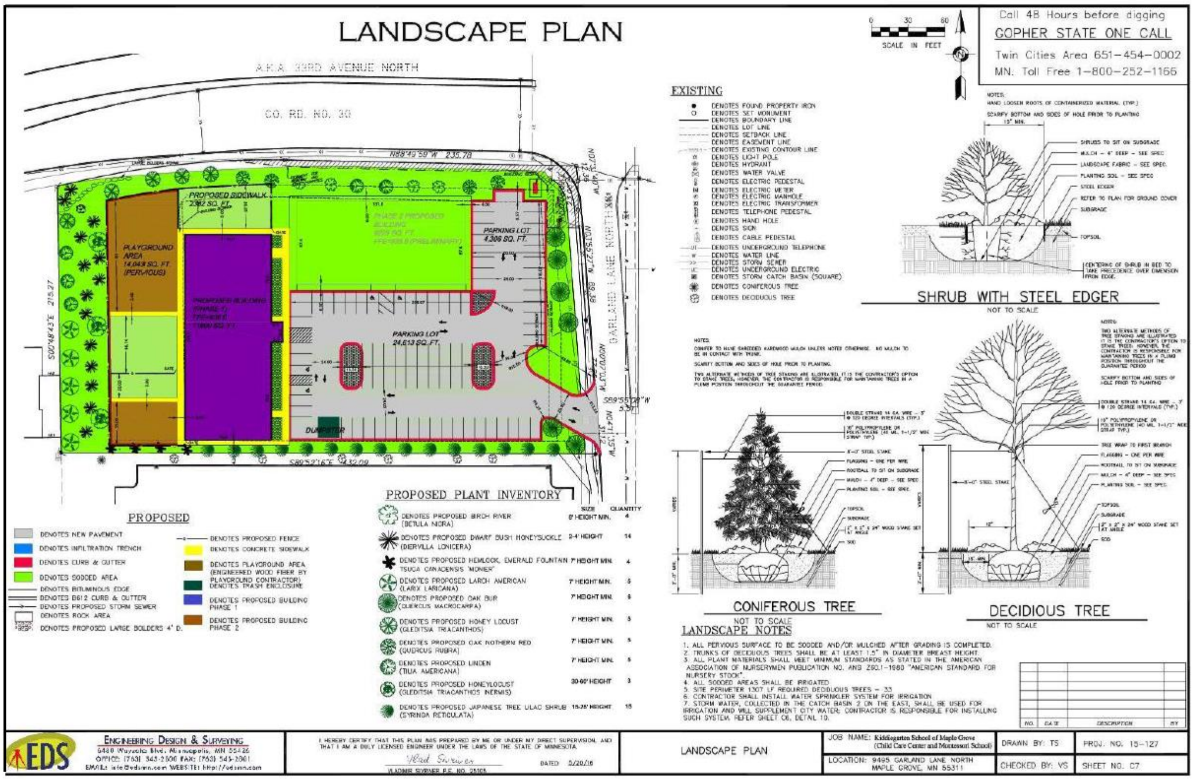

Figure 12. Landscape plan (Final version).

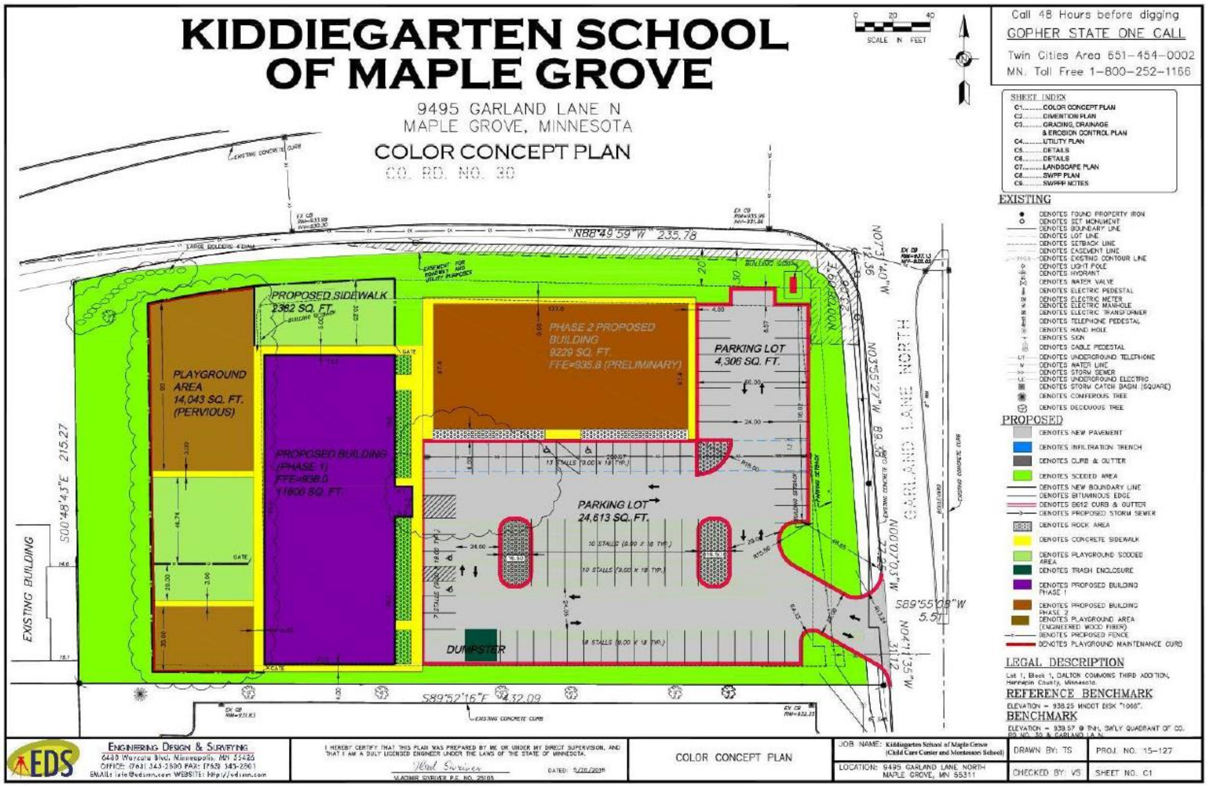

Figure 13. Color concept plan.

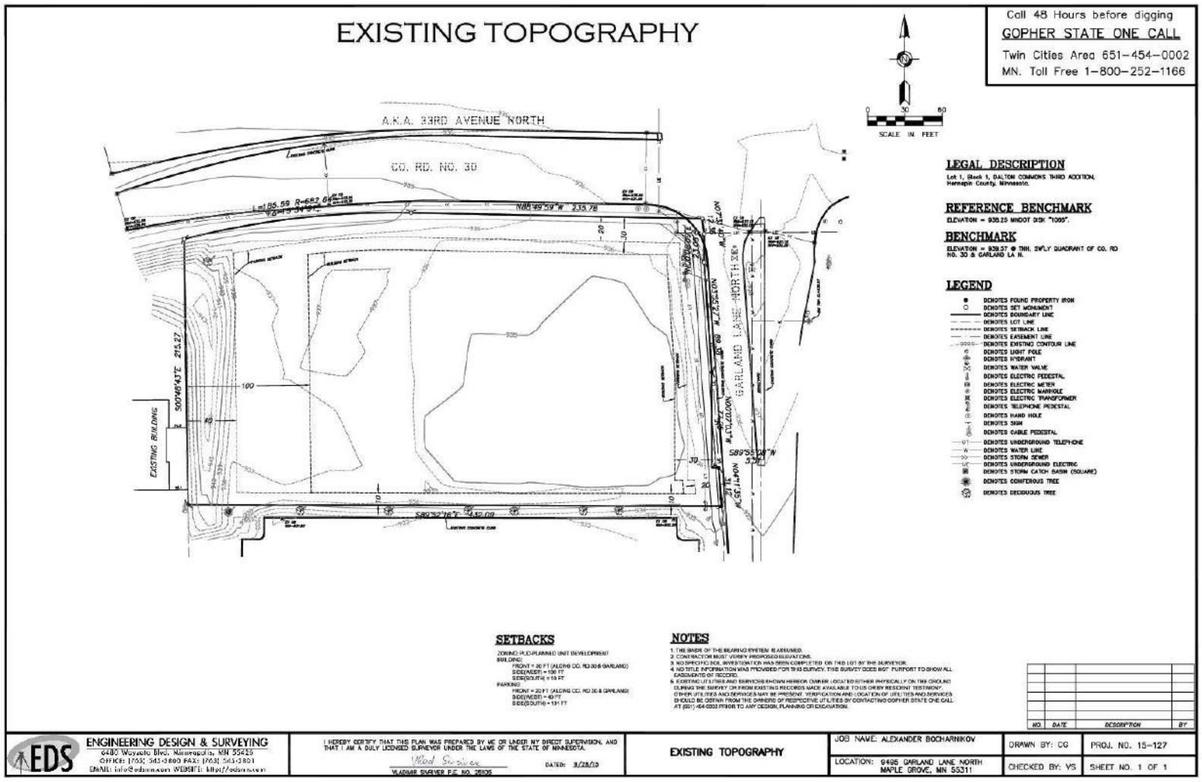

Figure 14. Existing site conditions.

Summary

Quantitative and qualitative approaches were used for the data analysis of different project parts.

Economic analysis was based on NPV and IRR methods; project structure analysis was done using WBS and responsibility matrix; requirements analysis was done to create design product, complying with rules and regulations; analysis of different available storm water management technologies was done to find the most suitable solution for this site and proposed facilities; quantitative approach was used to verify sufficiency of chosen technology. Project results and recommendations are presented in the next chapter.

Chapter V: Results, Conclusion, and Recommendations

Introduction

This chapter summarizes methodology and the results of all conducted data analysis; it presents it in question-answer format, to address project questions. It also gives recommendations how to use project results for managing future projects, feasibility studies and design solutions.

Results

Project used combined quantitative and qualitative analytical methods to find the best design solutions, to conduct feasibility study and to effectively manage the design process. Numerous amount of requirements for different areas of designed was studied and applied. Numerous amount of data for storm water calculations was derived from the design plans; sophisticated computer models were used to make sure that the chosen stormwater management technology was designed to comply with watershed acceptance criteria. As a result a set of civil design plans was developed in a timely manner, submitted for the PUD stage development approval and to the watershed district for design concepts approval.

The project addressed questions from three areas: engineering economy, project management and civil design.

Engineering economy:

- Is chosen site location beneficial for the chosen business type and why?

Based on the competitor analysis, there are only two direct competitors within one mile radius. This makes market very unsaturated, and good for business.

Based on the target market capacity analysis, at the ZIP level, only 19.1% of the available capacity is being served using the licensing information available at the website of Department of Human Services, and the city level, only 34.5% of the available capacity is being currently served. There is a capacity to serve even by analyzing competition map of 1/3/5 mile radius using circular area profiling.

- What kind of benefits this business will bring to the community and investor?

Child care is a necessity and desire. Obtaining reliable, affordable and quality child care, is a major concern for many parents, particularly with the rise of families with both working parents. New affordable child care center will bring community opportunity to use local service.

Child care centers are small businesses which support strength of economy; they impact the economy by supporting working parents; and in a long term, by providing quality programs that prepare children for school and reduces costs for a whole range of social issues in the future.

- Will the project realization bring any profit?

The financial analysis shows good return on investment considering the revenue and operating costs, and the break-even point is within the first year of operations. The annual rate of return for the project is 10% at the steady state, and the break-even is happening in the eighth month of operations.

The key success factors for this investment are:

- Appropriate location: Identifying an appropriate location with less / unsaturated competition, and growing areas supported by income and age demographic projections.
- Financing: Availability of U.S. SBA financing with opportunity of fixer arm amortization.
- Timely DHS license: The DHS license can take six to none months to obtain, so timely application and issuance of license is important.
- Quality staffing: Quality staffing is key in meeting the dynamics of student-teacher ratio and rules compliance.
- Enrollments beyond break-even point: Ability to obtain enrollments beyond break-even point within first year of operations due to heavy fixed costs
- Ongoing licensing compliance: Ensuring there are no significant licensing violations to prevent loss of reputation and eventual license revocation.

Project management:

➢ What does this project include? What is needed to be done?

For successful project management, management organization should clearly understand what this project include. Work breakdown structure was created (see Figure 10) for project planning, assigning responsibilities. Main deliverables of the design project, taking project limitations into consideration, were: set of required civil design plans, submitted to the City; set of plans and calculations, submitted to the Elm Creek Watershed and project narrative.

- What are main project milestones?

For successful project planning deadlines should be identified. The deadline for the design project was the submission date for the City of Maple Grove Planning Commission. The length of the preliminary design stage of this project was approximately 3 months, which is a very short time for a big scope of work and amount of plans.

Civil design:

- What are the City of Maple Grove requirements for the new construction in this development zone?

There is an extensive list of requirements for this development zone in the City Code. Daycare conditional use is accepted, when the project meets certain requirements. Careful planning of all structures inside building and parking setbacks was done, based on that buildings sizes, playground area and parking lot sizes were maximized.

- What are the requirements for storm water and other utilities design?

There are three main criteria for the proposed storm water management: volume control, rate control and pollution control.

The volume control requirement was hard to meet, because of the low infiltration rate soil type on the site. To meet all criteria the water management system, consisted of infiltration trench and cistern for irrigation was designed.

Utility lines have limitations for their vertical and horizontal separation, project's challenge was to design utility lines, with minimum crossing, required elevations, going above the trench pipe, and supplying both stage 1 and stage 2 buildings.

- What is the specific of this project to be considered in civil design?

The project site is relatively small, so the effective use of space should be maximized. There is no room to place storm water treatment facilities.

The proposed facility is for kids' use, so design should include best available safe technologies; be child friendly.

A significant space for the playground was planned during design.

The construction will be conducted in two stages, it should be considered during civil design: the Phase 2 building was placed on the plan, Phase 2 parking lot, utility lines and valves were planned for the Phase 2 building.

The natural site condition was examined before design started, including soil reports. Soil reports showed very low infiltration coefficient, which created difficulty with managing storm water volumes.

Small size of the lot and relatively high percentage of impervious surface created difficulties to apply common storm water treatment practices.

Deep research had to be done to find best suitable technology for storm water management.

Besides all of this difficulties, the project had very limited budget.

The design was supposed to be completed in less than 3 months, to meet the deadlines; that was a big challenge for project manager and design team.

Finalized civil design plans were presented in the previous chapter (Figures 9-14).

Conclusion

The project objective was to identify the economic feasibility of the project; to plan and manage design work; to create all the required plans and documents for every stage of design and new development approval process according to the City and customer requirements, using the best available solutions, meeting time and budget targets.

Literature research was done to identify methodology for feasibility studies, project management and civil design. Methodology for each part of the analysis was summarized. Initial data for economic analysis was obtained from the owner and NPV and IRR were calculated, showing good rate of return and positive NPV. Initial data for project management was obtained through analyzing the scope and creating

WBS, the tasks were assigned and the project work was scheduled. Civil design was very unique and specific; it demanded some extra time spend on research and requirements gathering. Storm water management was one of the most challenging parts of the project, but was successfully completed by adapting the new infiltration trench with TDA technology and stormwater usage for irrigation.

A completed set of plans and documents for PUD application development and Elm Creek Watershed application, were completed on time, and approved after some minor changes, based on the expert's recommendations.

After a longer period of detailed design for construction, the project now is under construction face, which was not included in the scope of this paper. The opening ceremony expected in 2017.

Recommendations

Economic analysis showed a good return on investment in the child care sphere in Minnesota, and big demand for this services. Research can be used for similar projects feasibility studies.

Application of simple project management tools, like WBS and responsibility matrix, along with careful project planning lead to successful project completion, and can be recommended for use in small to medium design projects.

The results of a deep research, regarding civil design requirements, can be used for future design projects in this area.

Some findings for the stormwater management on this specific site, and application of combined technology, give a good base for future design work in similar conditions.

High attention to details and collaborative team work is recommended for future design projects. Owner, architect, consultant, designer, construction company representative should be involved during the design stage. Civil design is a complex process and required knowledge in different spheres.

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